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Studies on the effect of nitrogen, phosphorous and potassium on soil nutrient status of seed tuber production derived from apical rooted cuttings of potato (*Solanum tuberosum* L.) var. Kufri Badshah under central Telangana region

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Abstract
The present study, titled "Effect of Nitrogen, Phosphorus, and Potassium on Soil Nutrient Status of Seed Tuber Production Derived from Apical Rooted Cuttings of Potato (*Solanum tuberosum* L.) var. Kufri Badshah under Central Telangana Region," was conducted during the *rabi* season of 2023-2024 at the Fruit Research Station, Sangareddy, Sri Konda Laxman Telangana Horticultural University. The experiment employed a Randomized Block Design with seven NPK treatments each replicated three times.
The results demonstrated that treatment T_7 (150:125:150 NPK kg/ha) had recorded highest yield/ha (15.6 t/ha), maximum difference in available nitrogen (128.54 kg/ha), phosphorous (62.52 kg/ha) and potassium (112.46 kg/ha) before and after harvest and also shown maximum availability of nitrogen (256.46 kg/ha), phosphorous (92.48 kg/ha) and potassium (342.54 kg/ha) in the soil after harvest of the crop. It also recorded highest electric conductivity (0.41 dS/m) and lowest pH (7.01) in the soil after harvest.
This study highlights the potential of optimized NPK management to improve potato production, particularly in the region under study.

Keywords: Potato, Kufri Badshah, apical rooted cuttings, nitrogen. phosphorous, potassium, electric conductivity, pH

1. Introduction

Potato (*Solanum tuberosum* L.) is one of the most widely consumed tuber crops globally, playing a crucial role in food security (Karam *et al*., 2009) [1]. Belonging to the Solanaceae family, potatoes originated in the Andean regions of Peru and Bolivia in South America, characterized by a basic chromosome number of x=12 (Hawkes, 1990) [2]. Over time, the crop has become a global staple, cultivated commercially worldwide. Introduced to India by Portuguese traders in the 17th century, potato cultivation expanded to North India during the British colonial period (Nath *et al*., 2008) [3]. India is the world's second-largest potato producer, with 2.34 million hectares under cultivation, yielding 60.22 million metric tons at a productivity rate of 25.74 metric tons per hectare. Leading states include Uttar Pradesh, West Bengal, Bihar, Madhya Pradesh, and Gujarat. South India's potato cultivation began in recent years, with Telangana State contributing 34,650 metric tons from 1,390 hectares in parts of Medak and Rangareddy, achieving a productivity rate of 24.92 metric tons per hectare (Anon., 2024) [4].

Potato is traditionally propagated by tubers. However, in India, potato yields are often limited by the high cost and limited availability of quality seed tubers, which account for over half of production costs. True Potato Seed (TPS) technology, though requiring just 100-150 grams per hectare, is labor-intensive and produces less uniform crops with lower market value (Kumar, 2014) [5].

Aeroponics has emerged as a high-yield seed tuber multiplication method with a 1:10

multiplication ratio, but its high costs and labor demands limit large-scale use (Mateus-Rodriguez *et al*., 2013) [6]. A more cost-effective alternative is the use of apical rooted cuttings (ARC). The Apical Rooted Cutting (ARC) technology enables efficient, low-cost local production of high-quality seed potatoes. Certified mother cultures are multiplied in tissue culture labs, and apical cuttings are taken every 15 days from mother blocks for rooting. These rooted plants are transplanted into fields once they reach 15 cm in height (15 days old). ARC is highly suitable for Telangana, providing an affordable solution to meet farmers' seed potato needs (Kumar and Amrutha, 2023) [7].

Potatoes require a balanced application of nutrients to enhance crop yield. Nitrogen enhances growth, development, and quality through leaf area expansion, crop development, and susceptibility to lodging (El-Ghamriny and Saeed, 2007) [8]. Phosphorus is crucial for vine growth, tuber formation, and starch synthesis (Hopkins *et al*., 2014) [9]. Potassium is essential for photosynthesis, carbohydrate metabolism, water regulation, and nitrogen uptake (Kelling *et al*., 1998) [10].

2. Material and methods

A field experiment entitled "Studies on the effect of nitrogen, phosphorous and potassium on soil nutrient status of seed tuber production derived from apical rooted cuttings of potato (*Solanum tuberosum* L.) var. Kufri Badshah under Central Telangana region" conducted during *rabi*- 2023-24, at Fruit Research Station, Sangareddy, SKLTSHU. The experiment was laid out in a Randomized Block Design (RBD) with seven NPK treatments: T_1 (100:50:75 kg/ha), T_2 (100:50:100 kg/ha), T_3 (125:50:125 kg/ha), T_4 (100:75:100 kg/ha), T_5 (125:75:100 kg/ha), T_6 (125:100:125 kg/ha), and T_7 (150:125:150 kg/ha) and replicated thrice with plot size: 3×3 m^2 and spacing: 50 cm ×30 cm. Full dose of phosphorous was applied as basal dose at the time of land preparation in the form of Diammonium phosphate. The total N and K_2O were split into three doses and were applied at 20, 40 and 60 DAT in the form of urea and potash respectively. The standard recommended package of practices of SKLTSHU was followed to raise the successful crop. The crop is harvested after 90 DAT and yield is calculated as tons/ha.

Table 1: Soil nutrient status before transplanting of apical rooted cuttings

S. No.	Particulars	Values	Method of analysis
1	pH (1:25 soil water suspension)	7.07	Beckman pH meter glass electrode method (Jackson, 1967) [11]
2	EC (dS/m)	0.23	Solubridge method (Jackson, 1967) [11]
3	Organic carbon (%)	0.35	Walkley and Black (1934) [12]
4	Available N (kg/ha)	235	Alkaline permanganate method (Subbiah and Asija, 1956) [13]
5	Available P_2O_5 (kg/ha)	30	Olsen's method (Olsen *et al*.1954) [14]
6	Available K_2O (kg/ha)	305	Flame photometry (Jackson, 1967) [11]

3. Results and Discussion

3.1 Yield: The maximum tuber yield per hectare was recorded by T_7- 150:125:150 kg/ha (15.6 t/ha) followed by T_6-125:100:125 NPK kg/ha (14.2 t/ha). Lowest was recorded in T_1-100:50:75 kg/ha (11.3 t/ha).

The greater vegetative growth observed with more fertilizer application may have led to the higher tuber yield. High nutrient availability increased plant's entire leaf area, increasing its ability to intercept solar light. Phosphorous is essential for assimilate translocation, higher potassium increased photo-assimilate production and assimilation, which were then directed to the tubers (Zelalem *et al*., 2009) [15].

Table 2: Effect of nitrogen, phosphorous and potassium on yield of potato apical rooted cuttings var. Kufri Badshah

Treatments	Total tuber yield per ha (t/ha)
T_1-100:50:75	11.3
T_2-100:50:100	11.9
T_3- 125:50:125	13.1
T_4-100:75:100	12.3
T_5- 125:75:100	12.6
T_6-125:100:125	14.2
T_7-150:125:150	15.6

3.2 Nitrogen: Data pertaining to difference in nitrogen, phosphorous, potassium before harvest and after harvest is presented below (Table 3, 4, 5).

Maximum difference is shown by T_7- 150:125:150 NPK kg/ha (128.54 kg/ha) followed by T_6- 125:100:125 NPK kg/ha (117.25 kg/ha). Least difference is shown by T_1- 100:50:75 kg/ha (93.40 kg/ha).

3.3 Phosphorus

Maximum difference is shown by T_7- 150:125:150 NPK kg/ha (62.52 kg/ha) followed by T_6- 125:100:125 NPK kg/ha (61.3 kg/ha). Least difference is shown by T_1- 100:50:75 kg/ha (55.45 kg/ha).

3.4 Potassium

Maximum difference is shown by T_7- 150:125:150 NPK kg/ha (112.46 kg/ha) followed by T_6- 125:100:125 NPK kg/ha (102.58 kg/ha). Least difference is shown by T_1- 100:50:75 kg/ha (81.68 kg/ha).

The study suggests that increased fertilizer dosage directly impacts plant nutrient absorption, with increased NPK levels leading to increased soil nutrient levels post-fertilizer addition and post-crop harvest, indicating increased crop output and vegetative growth, while causing greater soil nutrient loss (Irfan *et al*., 2016 [16] and Kumar, 2017 [17].

Table 3: Effect of nitrogen, phosphorous and potassium on soil nitrogen status of potato apical rooted cuttings var. Kufri Badshah

Treatments	Nitrogen kg/ha				
	Initial status	Addition of nutrients through fertilizer	Total	Final status after harvest	Difference
T_1-100:50:75	235	100	335	241.60	-93.40
T_2-100:50:100	235	100	335	237.44	-97.56
T_3- 125:50:125	235	125	360	253.47	-106.53
T_4-100:75:100	235	100	335	233.74	-101.26
T_5- 125:75:100	235	125	360	255.94	-104.06
T_6-125:100:125	235	125	360	242.75	-117.25
T_7-150:125:150	235	150	385	256.46	-128.54

Table 4: Effect of nitrogen, phosphorous and potassium on soil phosphorus status of potato apical rooted cuttings var. Kufri Badshah

Treatments	P_2O_5 (kg/ha)				
	Initial status	Addition of nutrients through fertilizer	Total	Final status after harvest	Difference
T_1-100:50:75	30	50	80	24.55	-55.45
T_2-100:50:100	30	50	80	22.91	-57.09
T_3- 125:50:125	30	50	80	20.88	-59.12
T_4-100:75:100	30	75	105	46.87	-58.13
T_5- 125:75:100	30	75	105	46.27	-58.73
T_6-125:100:125	30	100	130	68.7	-61.3
T_7-150:125:150	30	125	155	92.48	-62.52

Table 5: Effect of nitrogen, phosphorous and potassium on soil potassium status of potato apical rooted cuttings var. Kufri Badshah

Treatments	K_2O (kg/ha)				
	Initial status	Addition of nutrients through fertilizer	Total	Final status after harvest	Difference
T_1 -100:50:75	305	75	380	298.32	-81.68
T_2-100:50:100	305	100	405	319.567	-85.43
T_3- 125:50:125	305	125	430	336.79	-93.21
T_4-100:75:100	305	100	405	316.4	-88.6
T_5- 125:75:100	305	100	405	313.94	-91.06
T_6-125:100:125	305	125	430	327.42	-102.58
T_7-150:125:150	305	150	455	342.54	-112.46

3.5 Available nitrogen
Data pertaining to available nitrogen, phosphorous, potassium, EC and pH of soil after harvest of the crop is presented in table 6 and Fig 1.

There was a significantly higher nitrogen availability in the soil after harvest in T_7- 150:125:150 NPK kg/ha (256.46 kg/ha), which was statistically on par with T_5- 125:75:100 NPK kg/ha (255.94 kg/ha) and T_3- 125:50:125 NPK kg/ha (253.47 kg/ha).

3.6 Available phosphorous
Available phosphorous in the soil after the harvest was more in T_7- 150:125:150 NPK kg/ha (92.48 kg/ha) followed by T_6-125:100:125 NPK kg/ha (68.70 kg/ha).

3.7 Available potassium
T_7- 150:125:150 NPK kg/ha had shown significantly more potassium availability in the soil (342.54 kg/ha) after the harvest of the crop which was statistically on par with T_3- 125:50:125 NPK kg/ha (336.79 kg/ha).

3.8 Available pH: No notable difference among the treatments were noted. Still the maximum was recorded by T_1- 100:50:75 kg/ha (7.06 pH) while the minimum pH was recorded by T_7-150:125:150 NPK kg/ha (7.01 pH).

The study found a slight pH dip with increased fertilizer doses, particularly nitrogen as they are taken in the form of urea and DAP which were ammoniacal form of nitrogen, which undergo nitrification which release H^+ ions, causing the soil's pH to decrease (Kumar, 2017) [17].

3.9 Available EC
We could observe that maximum EC was recorded by T_7-150:125:150 NPK kg/ha (0.41 dS/m) which was statistically on par with T_6- 125:100:125 NPK kg/ha (0.38 dS/m), T_3-125:50:125 NPK kg/ha (0.37 dS/m) and T_5- 125:75:100 NPK kg/ha (0.36 dS/m). The minimum EC was recorded by T_1-100:50:75 kg/ha (0.31 dS/m) after the harvest.

The study suggests that soil electric conductivity increases with increased fertilizer doses, possibly due to increased concentration of soluble salts in the soil (Kumar, 2017) [17].

Table 6: Effect of nitrogen, phosphorous and potassium on soil nutrient status after harvest of potato apical rooted cuttings var. Kufri Badshah

Treatments kg/ha	Soil nutrient status after harvest				
	Available N (kg/ ha)	Available P_2O_5 (kg/ha)	Available K_2O (kg/ha)	pH	EC (dS/m)
T_1-100:50:75	241.60^{bc}	24.55^{d}	298.32^{d}	7.06	0.31^{bcd}
T_2-100:50:100	237.44^{bcd}	22.91^{de}	319.57^{bc}	7.05	0.33^{bc}
T_3- 125:50:125	253.47^{abc}	20.88^{def}	336.79^{ab}	7.03	0.37^{abc}
T_4-100:75:100	233.74^{c}	46.87^{c}	316.40^{c}	7.04	0.35^{b}
T_5- 125:75:100	255.94^{ab}	46.27^{cd}	313.94^{cd}	7.03	0.36^{abcd}
T_6-125:100:125	242.75^{b}	68.70^{b}	327.42^{b}	7.02	0.38^{ab}
T_7-150:125:150	256.46^{a}	92.48^{a}	342.54^{a}	7.01	0.41^{a}
Grand Mean	245.91	46.09	322.14	7.03	0.36
S.E(m)±	2.36	1.30	2.99	0.02	0.02
C.D at 5%	7.26	4.01	9.21	NS	0.05
C.V	1.66	4.89	1.61	0.53	8.50

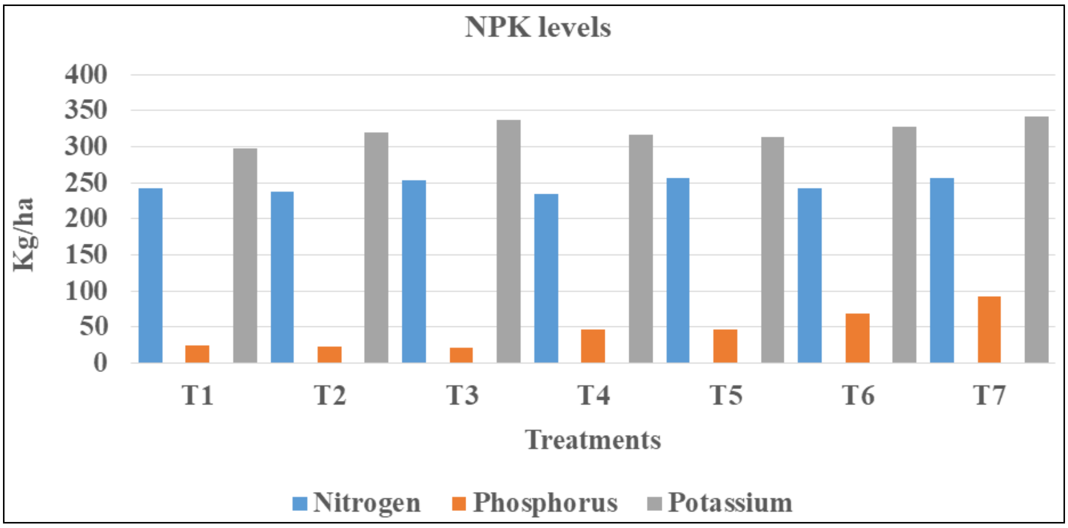

Fig 1: Effect of nitrogen, phosphorous and potassium on soil nutrient status after the harvest of potato apical rooted cuttings var. Kufri Badshah NPK kg/ha

T_1- 100:50:75	T_2- 100:50:100	T_3- 125:50:125	T_4- 100:75:100
T_5- 125:75:100	T_6- 125:100:125	T_7- 150:125:150	

4. Conclusion

The present study demonstrated highly significant variations among the seven fertilizer treatments concerning yield and soil nutrient status in seed tuber production derived from apical rooted cuttings of potato (*Solanum tuberosum* L.) var. Kufri Badshah. The highest tuber yield (15.6 t/ha), maximum difference in nitrogen (128.54 kg/ha), phosphorous (62.52 kg/ha) and potassium (112.46 kg/ha) after harvest and also maximum availability of nitrogen (256.46 kg/ha), phosphorous (92.48 kg/ha) and potassium (342.54 kg/ha) in the soil after harvest of the crop is recorded in T_7- 150:125:150 NPK kg/ha. The highest electric conductivity (0.41 dS/m) and lowest pH (7.01) in the soil after harvest of the crop is also recorded by T_7- 150:125:150 NPK kg/ha.

Future studies could focus on the long-term effects of these fertilizer treatments on soil health and sustainability, which would be beneficial for developing region-specific nutrient management strategies.

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